Preliminary

EG&G RETICON

LC1922
Dual Color
Modular Line Scan Camera

Introduction

The LC1922 dual color modular line scan camera is a compact, high performance, rugged industrial camera. The LC1922 features a two-channel time-division multiplexed video format which represents the output from alternate charge coupled photodiode elements. These elements are filtered for red and green transmission which are output on each channel respectively. It is constructed to operate and survive in harsh industrial environments while delivering the performance and precision required in the laboratory.

Applications for the LC1922 camera include high-speed data acquisition, agriculture vision, process control and monitoring, biomedical imaging, remote sensing, and many other industrial and scientific applications.

Figure 1. LC1922 Camera

Key Features

- Monolithic filter process
- Red - Green color discriminated output
- Geometrically precise charge-coupled photodiodes
- 2048 element solid state image sensor
- Good support hardware
- High-speed data rates to 20 MHz
- Line reset exposure control (electronic shutter)
- Antiblooming
- Rugged construction for industrial environments
- Differential digital I/O signals for electrical noise immunity
- Sensor is bore-sighted, angular-corrected, and referenced to precision registration holes
- Scan rates to over 70,000 scans per second
- Removable through-the-lens viewer (optional)

General Description

The LC1922 Line Scan Camera is a precision electro-optical instrument housed in a compact, lightweight, and extremely rugged enclosure. The image sensor has been processed using polyimide dyes of alternating red and green over the photodiode sites. This monolithic process has superior registration of the filter material versus existing glass filter processes. This results in excellent consistency of performance from unit to unit. Internal construction utilizes shock absorbing interconnection materials and highly reliable hybrid circuitry to guarantee continued operation under conditions that could destroy conventional cameras.

The LC1922 camera senses light input from a scene and converts it into an analog video signal. The amplitude of the video is a linear function of the incident illumination from the scene. Electronic shuttering and antiblooming structures within the sensor ensure superior performance over a wide range of lighting conditions. Full control is provided over integration time and video data rate allowing the user to dynamically correct for variations in illumination found in "real-world" application environments. The LC1922 is available with a 2048 photo-element arrays so that the most stringent spatial resolution can be met.

Functional Description

The LC1922 camera contains a high performance line scan image sensor which converts incident light on each photodiode into discrete charge packets. After an appropriate integration period, the charge packets are transferred into two high-speed CCD shift registers and transported to the output of the device. Video from the sensor is processed by a unique hybrid microcircuit designed by Reticon to deliver peak performance and exceptional reliability.

Video output from the LC1922 is comprised of two time-division multiplexed serial data streams. Odd numbered pixels are output as "red" on one channel and even numbered pixels are output as "green" on the other. This "odd and even" output scheme allows the color represented video to be output from separate channels which reduces the cost and complexity of external processing hardware.

Camera operation is controlled by three externally generated, differential input signals. The frequency of the master clock input determines the video data rate; the period of the line transfer input defines the line scan rate; and the line reset signal, when used in conjunction with the line transfer input, controls the integration period. The flexibility of this arrangement allows video data rates up to 20 MHz, line rates exceeding 70,000 scans per second, and provides an electronic exposure control.

This direct control over camera speed and pixel integration time allows the data rate to be set to a convenient readout speed for external processing hardware while allowing an integration time appropriate to capture higher speed events. The electronic exposure control combined with the anti-blooming circuitry allows the camera to operate over the widest possible range of lighting conditions.

Electrical Configuration

Camera operation requires ±12VDC and +5VDC power, a single phase clock, and a line transfer pulse. All digital input and output signals are differential line pairs conforming to EIA RS422 specifications. The video channels are 75Ω, single-ended outputs. Custom shielded cable is available from Reticon in lengths of one hundred foot multiples for operation at remote locations or in electrically noisy environments.

LC1922 series camera electronics are contained on two custom hybrid circuit modules within the camera housing. The circuit modules process control signals from the user, generate bias and drive signals for scanning of the photodiode array, and present the analog video and digital output signals to the user. All electrical connections to and from the camera are via a single 25-pin D-subminiature connector on the camera's rear panel.

Operation

Camera video output is produced by scanning the array at a rate determined by the external master clock input signal. That rate may be any value from 50 KHz to 20 MHz and produces two time-division multiplexed trains of sampled video data having an amplitude proportional to the filtered light intensity and the line scan integration time.

The video outputs can be recombined into a contiguous pixel data stream or processed independently. In either case, a dynamic range of greater than 1000:1 (peak video/p-p noise, excluding clock coupling) is available for applications that demand high gray scale resolution. The "full line dynamic range" (peak video/peak-to-peak dark pattern) is typically better than 48 dB which provides superior performance in binary or thresholding applications.

The line scan time is determined by the time interval between external line transfer pulses. A long integration time is desirable for high sensitivity, while a short line scan time is desirable to obtain a sharp image of rapidly moving objects. The line scan time may be any value between (N+32) x 50 nanoseconds and 40 milliseconds, where N is the number of array elements. Integration times longer than 40 ms can introduce higher levels of dark signal which reduce the dynamic range of the sensor. Longer integration times are possible if the camera is cooled to reduce the dark current. The specific characteristics of the application such as light level and rate of object motion will determine the optimum setting.

The camera block diagram, as shown in Figure 2, illustrates the functional flow of signals and the connector pin assignments for LC1922. The specific timing characteristics and requirements can be found in Figure 3.

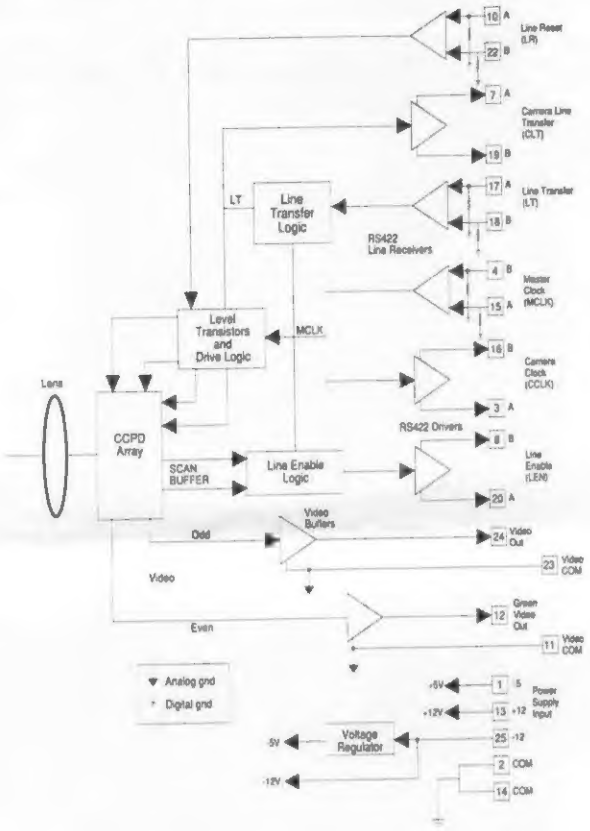


Figure 2. Camera Block Diagram

Sensitivity and Spectral Response

The LC1922 contains a high quality silicon photodiode line array that is responsive to wavelengths of light from below 350 nanometers (UV) to 1100 nanometers (near IR) as shown in Figure 4. The image sensor has color filter material processed over the elements in an alternating red, green pattern. The spectral response of the individual elements is illustrated in Figure 5. The response of the array to illumination is a function of sensor geometry and integration time. The LC1922 requires an IR blocking filter to remove the effects of the near IR component in the light source. The IR filter spectral transmission characteristics will determine the actual system spectral responsivity. The LC1922 camera is available with a 26 µm aperture device only.

Applications for these devices utilize visible light, therefore, sensitivity and photoresponse uniformity are specified using a light source with the spectral distribution shown by the dotted line in Figure 4. This spectral distribution is produced by filtering a 2870° K Tungsten source with a Fish Schurman HA-11 heat absorbing filter 1 mm thick.

Construction

The rugged LC1922 camera is constructed to survive and operate reliably under punishing shock and vibration conditions. Tests performed by an independent laboratory prove that the LC1902 can withstand shock up to 300G (peak) and random vibration in excess of 30G (RMS).

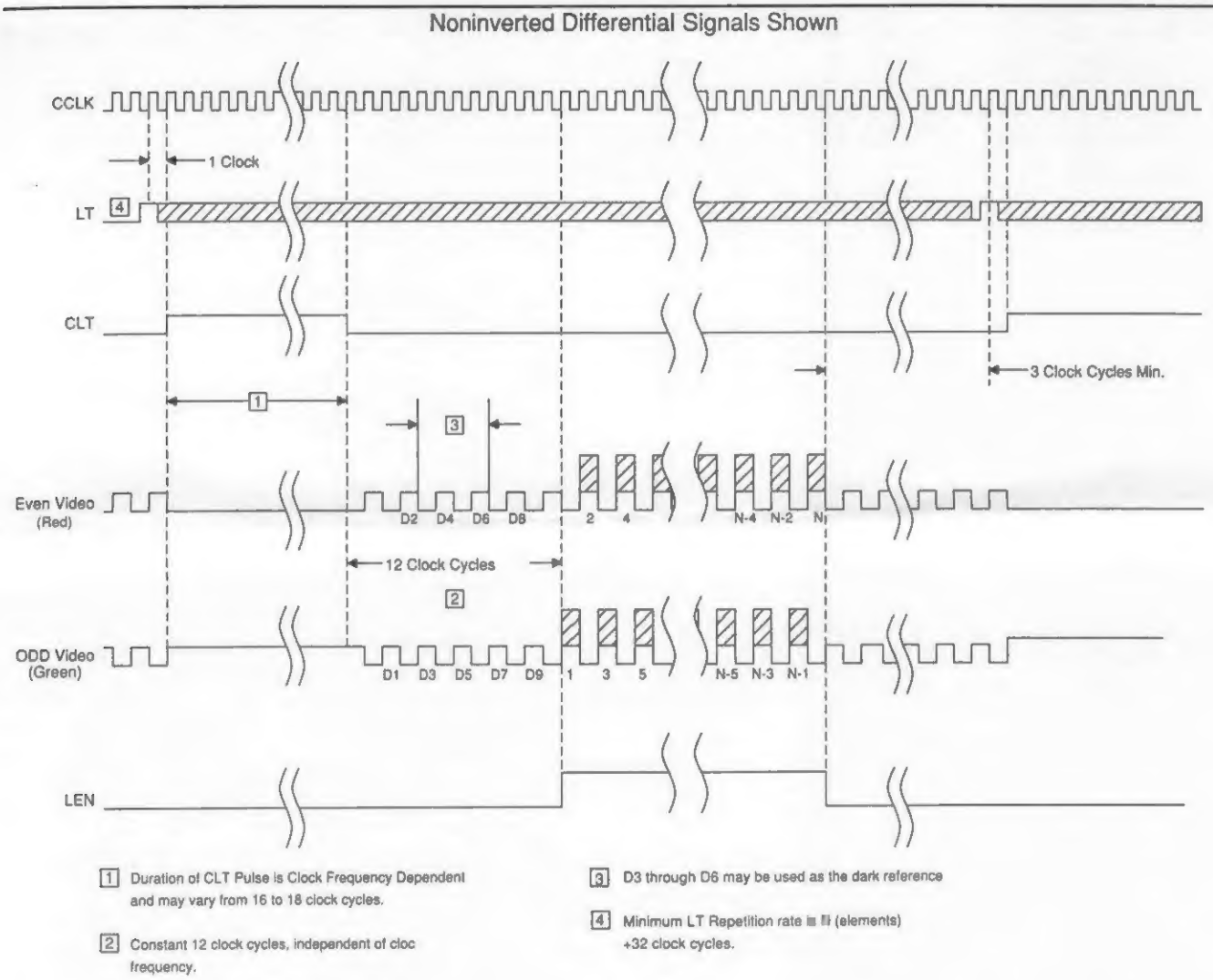


Figure 3. Timing Diagram

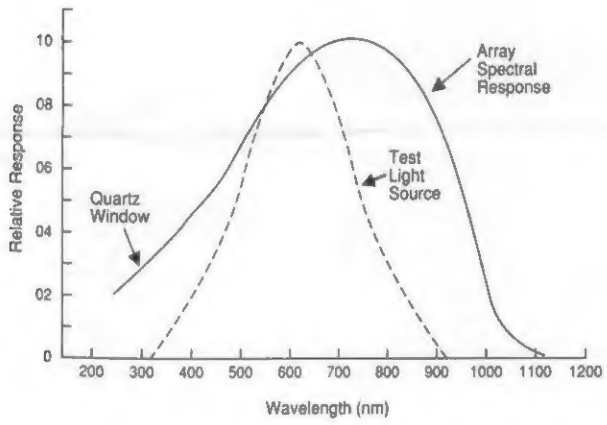


Figure 4. Relative spectral response of unfiltered device as a function of wavelength. Dotted line shows the spectral distribution of light source used for sensitivity measurements. Measurements taken using full array illumination and averaged relative output at test spectral frequencies. The standard LC1922 camera devices have quartz windows.

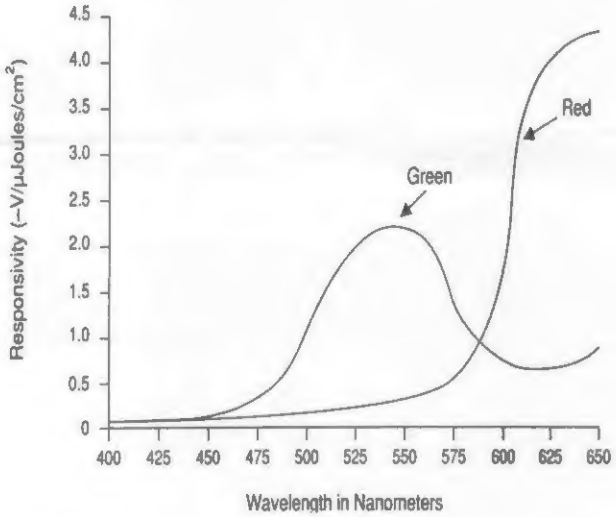


Figure 5. Spectral response as a function of μw/sec/cm² and wavelength. Measurements were taken using an HP Model 77200 Monochrometer with a 3160 μm slit and 1200 LPM grating.

The camera electronics is housed in a sturdy aluminum case. The hybrid microcircuits are laminated onto aluminum mounting plates which function as efficient heat transfer devices to the case. When used in extremely hot environments, the camera electronics may be conveniently cooled simply by cooling the case. The image sensor is thermally attached to the front aluminum plate and electrically connected to the front hybrid. The hybrids are interconnected via shock absorbing elastomeric conductors and the interconnect pc board is connected to the case-mounted D-subminiature connector via a flexible conductor strip.

The camera is provided with a standard 1/4-20 UNC tripod mounting plate which can be mounted on any of four sides of the camera case. The hole pattern used to fasten the tripod mounting plate can also be used to rigidly mount the camera assembly. An optional right angle bracket and circular mounting plate is also available for mounting flexibility. These mounting options contain registration pins which are designed to mate with corresponding precision holes on the camera face.

The sensor is precisely aligned to the registration pin holes. That allows the camera to be easily removed and remounted as may be necessary for lens cleaning or equipment servicing without complicated optical realignment. All LC1922 camera image sensors are aligned at the factory for X, Y and rotation with respect to the precision registration holes.

Optical

All LC1922 cameras are supplied with an adaptor for mounting Nikon "F" bayonet type lenses or accessories.

An optional through-the-lens viewer (Model CX9411) is available for use with the LC1922 camera to greatly simplify installation and alignment. With the appropriate lens adaptor, "U" or "F" mount optics and accessories can be used with the viewer. More information on selecting lenses, adaptors and extension tubes is available on Reticon's CX Series data sheet and Optical Calculation Worksheet.

Lenses and Optical Accessories

Reticon offers a line of optical accessories for the LC1922 camera. Products range from adaptors and extension tubes to high performance light sources. Reticon modular cameras have identical optical and mechanical configurations so that lenses and accessories can be interchanged from camera to camera.

Mounting and Other Accessories

EG&G Reticon offers a complete line of high quality mounting accessories for the LC1922 camera to facilitate optimum camera positioning. These include a heavy-duty right angle precision mounting plate, a circular precision mounting plate, and a camera head accessory tripod mounting block. One tripod mounting block is supplied with the camera.

Reticon also offers a variety of other camera products including a Video Data Formatter, Model MB1900, which supplies all the signals required for stand-alone operation of the LC1922 camera. Contact your local sales office for additional information or a demonstration.

Application Support

Reticon maintains a staff of highly skilled applications engineers to provide technical assistance and in-depth applications information. A library of technical articles and application notes is also available to assist our customers in the use of Reticon's machine vision products. Some examples of these are the following:

Depth of Field Characteristics using Reticon's Image Sensing Arrays and Cameras (AN #127)

Optical Calculation Worksheet (AN #126)

Design Considerations for a Solid State Image Sensing System (IA-6)

Modular Solid State Machine Vision Camera (C21)

Practical Illumination Concept and Technique for Machine Vision Applications (C22)

Specifications

Sensor Characteristics	
Center-to-center spacing	13 µm
Aperture width	26 µm
Spectral response [7]	Video A Video B

Operational Features	
Dynamic range	>1000:1 typical [5]
Video data rate	To 20 MHz [8]
I/O signals	Differential digital RS422
Video level	0.7V ±20% (terminated into 75Ω to -5V)
Video output impedance	75Ω
Weight	12 ounces (340 gm)
Dimensions	2.5" (H) x 2.5" (W) x 1.85" (D) 6.35 cm (H) x 6.35 cm (W) x 4.7 cm (D)

Control Signals	
Master clock (MCLK)	Controls readout speed
Line transfer (LT)	Initiates scan readout
Camera clock (CCLK)	MCLK synchronized to video
Enable (LEN)	Indicates presence of valid video
Line reset (LR)	Reset all photodiodes to zero integration level

Power Requirements	
+12V DC	135 ma (typ)
-12V DC	10 ma (typ)
+5V DC	153 ma (typ)
Input power	2.5W @ 2 MHz (typ) *

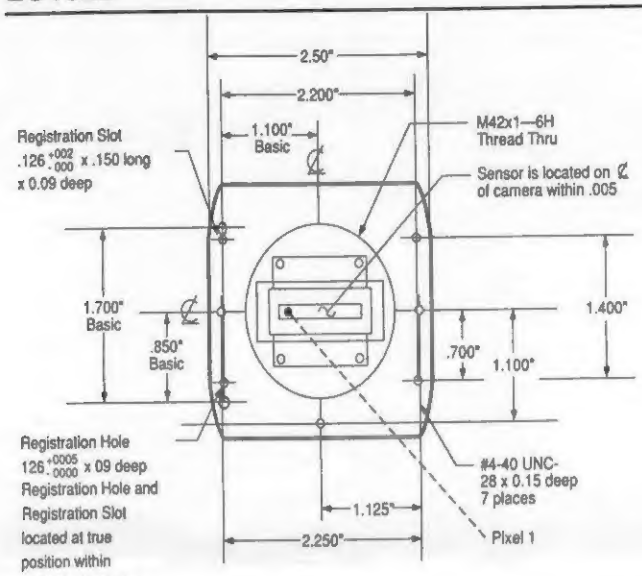
Performance	
Full line signal-to-noise ratio	>48 dB [4,6,7]
Light response nonuniformity	±6% max [1,2,6,7]
Saturation exposure	.22 microjoule/cm² @ 26 µm aperture
Exposure time (max) [3]	40 ms @ 25°
Shock	300G (peak)
Random vibration	30G (RMS)

Temperature	
Operating	0 to 55°C
Storage	-40 to 80°C

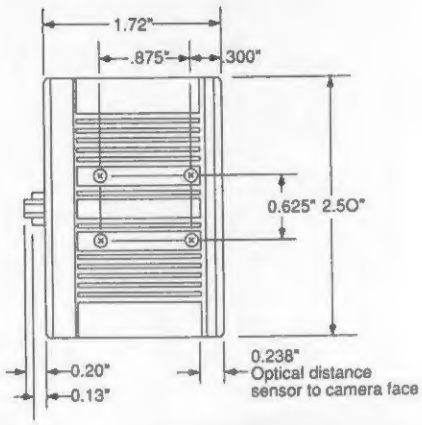
* Power consumption increases as clock rates increase

Notes:

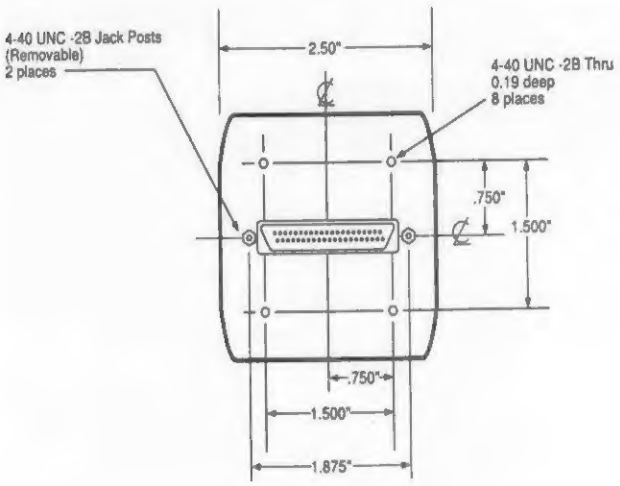
1. Light source is a 2870°K tungsten lamp filtered using a Fish Schurman HA11, 1 mm thick filter
2. Measured with uniform illumination at approximately 50% of saturation (first and last pixels ignored)
3. This exposure time will cause a dark leakage current of 8% or less
4. Use of line reset causes an increase in the fixed pattern
5. Dynamic Range = V_{SAT}/p-p noise (excluding clock coupling) @ 25°C
6. Full line S/N ratio = V_{SAT}/p-p fixed pattern noise
7. Refer to Figure 4 and 5 for Spectral Response Curve
8. For MCLK rates in excess of 8 MHz, use trailing edge of CLT to establish video synchronization.



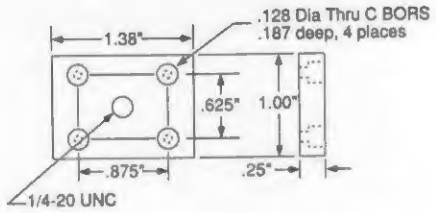
Front View



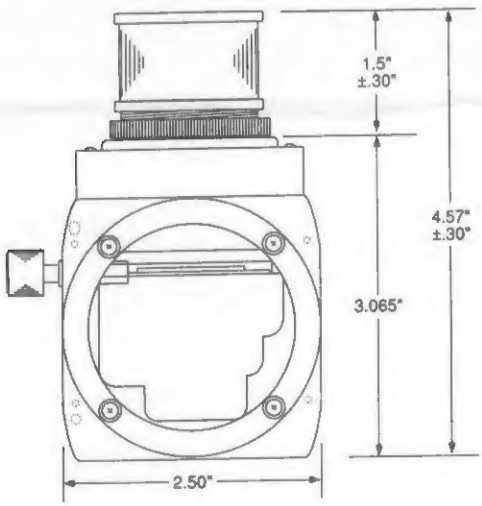
Side View



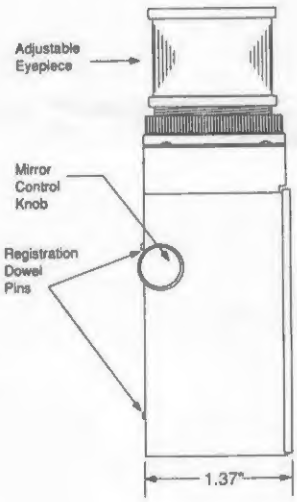
Back View



Standard Tripod Block Mounting Accessory



Front



Side

Thru-the-Lens Viwer (Optional)

Figure 6. Mechanical Drawing